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CHAPTER ONE

INTRODUCTION

A great deal has been written about rinderpest and detailed histories can be found in such texts as those of Hutyra et al (1938),Lepissier (1971) and the British Animal Health Divison (1965). In this report, therefore, a brief summary only is needed to illustrate the character of the disease and to identify factors relevant to its spread.

1.1 Rinderpest in Asia and Europe

Rinderpest is believed to have originated in China in pre-Roman times and spread to the Near East and Europe with stock brought in by successive invading forces. Descriptions of a disease in cattle resembling rinderpest can be found in writings on the Roman civilisation and numerous epidemics appear to have occurred in the centuries that followed.

Such epidemics were frequently associated with wars in which cattle were taken along as food reserves. A serious outbreak of rinderpest was certainly recorded during the Napoleonic wars in Europe, at the turn of the eighteenth century, and the last major epidemic in Western Europe developed at the time of the Franco-Prussian war in 1871-2. It involved France, Germany and Switzerland and led to restrictions on the movement of affected cattle and a slaughter programme which, together, eliminated the disease by 1890. In 1917, war again brought isolated outbreaks in Eastern Europe and, particularly European Russia, where the disease persisted until 1921. Whenever rinderpest occurred in susceptible cattle populations, mortality rates were high. Figures of the order of 60 - 80% were quire common, representing the deaths of millions of animals.

Whilst wars were often responsible for uncontrollable spread of rinderpest, peace time trade in live animals was also a source of danger. The great 'cattle plague' (rinderpest) epidemic in Britain in 1865 was linked to cattle imported from the Baltic States without adequate precautions. The Industrial Revolution and growth of cities had created such a large demand for meat that vast numbers of animals had to be brought in from Europe each year. Before the disease could be brought under control it had devasted the British livestock industry, killing as many as 65% of all the cattle in Cheshire. It was also spread to Holland by the importation of affected cattle from Britain. Strict control of movement and marketing, coupled with the slaughter of all affected herds brought about the eradication of rinderpest from Britain within two years. The characteristics of British Agriculture, with settled herds housed during the winter, undoubtedly contributed to this success and the previous experience of epidemics throughout Europe suggests that the normally limited mobility of cattle populations prevented the development of endemic rinderpest.

1.2. Rinderpest in Africa

Although some authorities believe there may have been earlier outbreaks, the first clear evidence of the disease in Africa was in cattle imported into Egypt from Rumania in 1841. A severe epidemic ensued and killed 75% of all the cattle and buffaloes in the country. The disease persisted in endemic form but with periodical upsurges of the infection which produced quite severe mortality. Africa south of the Sahara become infected for the first time in 1884 when rinderpest was introduced into Ethiopia during the course of a war. It spread through the countries to the west and appears to have reached and spread throughout West Africa in the period 1885 - 1886.

The great epidemic in Eastern and Southern Africa began with the movement of stock to Somalia from Aden in 1889. From there it spread relentlessly and disastrously towards South Africa which became infected in 1896. Determined efforts to control the spread included a 1,000 mile long fence which limited the movement of cattle and people but this only delayed the extension of the disease. Very high mortalities occurred in all the countries affected, not only among cattle but also among game species. Phrases such as 'ruin and devastation over vast areas of country' occur in the descriptions of the effects of the epidemic in South Africa.

The problem persisted in many other parts of Africa and a more detailed account of rinderpest in Nigeria is given in Chapter 3. Further major epidemics occurred occasionally, but the effects were never quite as severe as those following the first introduction of the infection. As veterinary services developed, there was a general improvement in the effectiveness of control programmes. New vaccines gave added protection and less undesirable reactions. Rinderpest outbreaks were still, however, a frequent hazard in East and West Africa until the 1950 - 60 period.

1.3. **International Co-operation**

In 1948 an African Conference on Rinderpest held in Nairobi gave new impetus to co-ordinated action by proposing the creation of a special 'Bureau' to deal with the problem. This led to the establishment of the Inter-African Bureau of Epizootic Disease (I.B.E.D.) in 1952, under the auspices of the Co-ordinating Committee for Technical Co-operation (C.C.T.A.) in Africa south of the Sahara. In 1960 I.B.E.D. was transformed into the Inter African Bureau of Animal Health (I.B.A.H.) and became an agency of the Organization of African Unity (O.A.U.). The creation of the Scientific, Technical and Research Commission (S.T.R.C.) by O.A.U. in 1965 gave added strength to animal health activities through I.B.A.H. To its Director, the late W.G. Beaton, C.B.E., FRCVS, DTVM, must go a large part of the credit for the initiatives that led toward rinderpest eradication.

1.4. **Joint Project 15**

The C.C.T.A. and the Foundation for Mutual Assistance in Africa (F.A.M.A.) began to develop a programme aimed specifically at the eradication of rinderpest. In May 1961 at a meeting in Kano, Nigeria, a regional campaign began to take shape in the form of 'Joint Project 15' (JP15). This provided for a phased programme to be financed by aid from various international and individual country sources. The evolution of the project has been described in detail by Lepissier (1971) who served as International Co-ordinator from 1961 - 69.

1.4.1. JP15 was conceived in the knowledge that no further improvement in rinderpest control could be expected without the co-ordinated programme for the very large areas in which nomadic, inter-country movement of stock was an essential part of cattle production. Such a schedule had been made technically feasible by the development of low cost vaccines which resulted in a strong and lasting — even life-time — immunity in cattle properly vaccinated. By maintaining vaccination campaigns during the appropriate seasons of each of two or three consecutive years, so that all bovines were vaccinated at least once, the cylce of transmission could, in theory, be broken. Follow-up campaigns to protect young stock born into the cattle population should prevent the establishment of any rinderpest that might be re-introduced.

1.4.2. The campaign was mounted in four phases. Phase I covered Cameroon, Niger, Nigeria and Chad, an area which enjoyed a tradition of cattle production and trading among related ethnic groups, particularly around Lake Chad. Despite the inevitable difficulties associated with such an ambitious programme, this phase was completed over the period 1962 - 65. Plans for Phase II were approved at a meeting in Bamako, Mali, in August 1962. As a result the programme was extended westward during the period 1964 - 67 to cover the remaining affected parts of Nigeria and Niger, as well as Dahomey, Ghana, Upper Volta, Togo and parts of Mali and the Ivory Coast. Phase III agreed in Bathurst, Gambia, in March 1964 included the remaining parts of Mali, the Ivory Coast and Chad, Gambia, Guinea, Liberia, Mauritania and Sierra Leone over the period 1966 - 69. The fourth phase took the programme into East Africa, where progressive stages have yielded similarly excellent results.

1.4.3. According to Lepissier, Phases I to III in Central and Western Africa cost the equivalent of approximately US $ 16.4 million. Of this US $ 7.2 million represented the expenditures of the individual African Governments and the balance was made up by contributions amounting to US $ 6.6 million from the European Development Fund, US $ 2.3 million from the United States Aid programme and approximately US $ 0.3 million from the British, Federal German and Canadian Aid programmes.

1.4.4. The results were spectacular. As the vaccination campaigns advanced through country after country, the incidence of rinderpest outbreaks fell from hundreds down to tens per year and then to, or very near, zero. Eradication of the disease was not achieved, but nowhere has the incidence of outbreaks returned to pre-campaign levels. The benefits have not been restricted to the reduced losses from rinderpest. The campaign has resulted in the development of veterinary services with the capability to undertake other major disease control and eradication programmes. The control of rinderpest should also have marked effects on the character of local cattle production systems and practices.

1.5. **Project Evaluation**

Such considerations led the United Kingdom Ministry of Overseas Development to enlist the help of the Animal Health Group at Reading University to devise means of assessing the impact of new animal health and production schemes under African conditions. JP15 appeared to be a convenient starting point and the Government of Nigeria offered to provide a base for the investigations. This has proved a fortunate choice, in that many of the national rinderpest programme records and staff who played key roles in JP15, were available for consultation.

1.5.1. In conducting the analyses and writing this report the authors' aim has been, not only to asses the economic return to the funds invested in JP15, but also to evolve suitable analytical techniques for exploring the deeper and wider implications of such animal health schemes. Perhaps the most important of these implications is the question of whether the control of rinderpest led to a larger cattle population which exacerbated the devastation caused by the sub-Sahelian drought in the early 1970's. Although data on changing cattle populations and herd structure was scarce, it has been possible to formulate a reasonably well supported hypothesis on this important issue which could markedly influence future production policy. Meanwhile, the case is certainly made for continued efforts to control major diseases and to develop new programme planning, evaluation and monitoring systems with appropriate data recording methods.

1.6. Acknowledgements

It would not have been possible to undertake this work without the generous support and day-to-day help of the staff of the Nigerian Government, the British High Commission in Nigeria and the Ministry of Overseas Development. So many people have helped the authors in their pioneering task that it is impossible to thank them all individually. However, the authors do wish to extend special appreciation to Drs. Inuwa Mohammed, Kelsey David-West, G.E.H. Stumpff-Lendner, Dennis Walker, Paul Leefland and Dele Oluokon for their constant help. They also wish to acknowledge the preparatory work done by Dr. C.B. Asby and to thank Drs. A.L.C. Thorne and J. Davie for their continuing support, encouragement and patience. Our thanks are also due to Mrs. A. Graves for patiently typing innumerable draft sections before this final version could be released.

CHAPTER TWO

THE EPIDEMIOLOGY OF RINDERPEST

The historic behaviour of rinderpest raises a number of interesting questions. Of particular relevance to this study is the need to explain why the disease failed to persist in Europe despite repeated introductions but became a continuing problem in Africa until a major international eradication campaign was implemented a decade ago. A further consideration is the reason for the dramatic response to this campaign in all areas, despite extremely difficult working conditions.

2.1. **Rinderpest** has been thoroughly described by many authors including Henning (1956), Hutyra *et al* (1938) and Merchant and Berner (1964). It is a highly contagious disease, characterised by a rapidly fatal febrile course in completely susceptible animals. Severe inflammation and necrosis occur in the mucous membranes, especially those of the digestive tract. Milder and even sub-clinical forms occur when the disease has become endemic or is frequently re-introduced. Rinderpest is primarily a disease of cattle. Other domestic ruminants might play a minor role in the spread of the disease as evidenced by serological responses recorded in sheep and goats in Nigeria (F.M.V.R. 1964-5) following contact with infected cattle. However, the practical risks of cattle rinderpest being spread by sheep and goats or infection of cattle with 'Peste de petits ruminants' seems negligible. Pigs can be affected and have been known to spread the infection between groups of cattle. However, pigs are uncommon in most of the cattle raising areas affected by rinderpest so their contribution to spread must be minimal. As already mentioned, wild ruminants are heavily involved in the epidemics of the disease in East Africa. However, so few wild ruminants remain in Nigeria, and probably throughout West Africa, that they are unlikely to play a part in the propagation of the infection and are even less likely to become a continuing reservoir of rinderpest.

2.2. Causes

The disease is caused by a myxo virus which has a diameter of 120-130 millimicrons, a well defined membrane, and is quickly inactivated by pH changes, heat, ultraviolet light and many disinfectants. The virus is, therefore very unstable outside the host, which accounts for the fact that indirect transmission by contamination of vehicles, stables, corrals and pastures seems to have been rare. A relationship to measles and canine distemper virus has been demonstrated through a common antigen but the diseases do not appear to be associated in the field. The relationship to the virus infecting sheep and goats (Peste de petits ruminants) has still to be fully defined.

2.3. Pathogenesis

2.3.1 Clinical signs usually follow experimental infection in three to six days. After natural exposure the incubation period is most commonly six to nine days but has been known to extend to fifteen days.

2.3.2. The common acute form of the disease frequently results in death in six to twelve days after onset. The first stage of the disease is characterised by a high fever lasting for several days. The fever may be accompanied by loss of appetite, reduction of milk yield, running eyes and the development of a harsh 'staring' coat. Profuse discharges develop from the mucous membranes of the mouth, nose, urinary tract and vagina. Severe diarrhoea appears as lesions develop in the abomosum and intestine. After a period of illness lasting 3 - 5 days, there is a sharp fall in temperature, accompanied by exacerbation of the mucosal lesions, respiratory difficulty and severe dehydration. Prostration and death usually ensue within 24 hours of these severe signs.

2.3.3. The virus is excreted in the urine, discharges and faeces from just before the onset of fever. The amount of virus excreted rises with the fever and then falls but persists for a total of 10 - 15 days. Animals that survive recover slowly and suffer from low white blood cell counts for a long time. Pregnant animals that survive usually abort about six weeks after the onset of fever and virus can be recovered from their discharges for a further two weeks.

2.3.4. The course of the disease varies with the natural resistance of the animal and the virulence of the virus strain. The dwarf cattle in the south of Nigeria, for example, appear especially susceptible. Attenuated virus in dried goat tissue vaccine causes severe reaction and even death in this breed while it is inocuous to other Nigerian breeds of stock. Inapparent reactions can occur in partially resistant animals in recently exposed populations, the symptons being so minor as to pass unnoticed. Such animals are, of course, a dangerous source of further spread, as was found in Belgium in June 1920 and in Brazil early in 1921. In these connected outbreaks cattle being shipped from India to Rio de Janeiro were temporarily unloaded in Antwerp and came into contact with other cattle imported from Germany which were subsequently distributed to farms in Belgium. Rinderpest developed on several of these Belgian farms. When the Indian cattle were shipped onward to Brazil they caused the only outbreaks of rinderpest ever recorded in Latin America. The condition was not recognised as rinderpest, at first, although some cattle had died in Belgium, and no post mortems were done because the disease was not thought to be infectious (Henning 1956).

2.4. Spread of the Disease

It is generally agreed that the spread of rinderpest is by direct contact and that spread between herds is, therefore, due to the movement of live infectious animals. The virus does not appear to be able to survive outside the host for more than a few hours and inside a carcase it is inactivated within 24 hours. Since the virus is excreted in the faeces, discharges and, particularly, urine of each animal for up to three weeks it is through these materials that infection must occur. There is little evidence that droplet infection is of any importance and a carrier state in the classical sense, does not appear to develop. If an animal recovers from rinderpest it is solidly immune and seems unable to infect other animals beyond the clinical phase.

2.5. Complications

In some cases other diseases complicate rinderpest outbreaks. Latent protozoal conditions such as babesia or trypanosome infections may be activated by the weakening of their hosts and secondary deaths may result. Non-protozoal secondary reactions are less common but contagious bovine pleuropneumonia (C.B.P.P.), streptothricosis and heartwater have been implicated.

2.6. Epidemiology

The epidemiology of the disease is determined by the interaction between the nature of the disease process in individual animals and the character of the production system in which it is encountered. These factors, together with the marketing and movement patterns which affect contact between infectious and susceptible animals govern the severity, rate of progress, distribution and extent of outbreaks. Thus in the small, settled, herds of Europe the pattern of rinderpest was, and would still be, quite different from that of Africa. The settled nature of the cattle populations naturally restrict spread and make control and eradication much simpler problems.

2.6.1. In contrast to Europe the spread and effects of rinderpest in Africa may have been enhanced by the following factors:

1. Cattle populations were large and appear to have been completely devoid of resistance to infection at the outset.
2. The large, free ranging, susceptible game animal population could have contributed to the spread and maintenance of infection, as well as complicating quarantine measures.
3. A large proportion of the cattle population was kept by nomadic herdsmen and, hence, movements and contacts between cattle were much more frequent and extensive than in settled farming systems.
4. The marketing process involved collection of cattle from many different herds and trekking groups to consumers in distant markets.
5. The pattern of dry and wet season grazings, and the tsetse fly zones that changed from season to season, necessitated high concentrations of cattle over certain periods and dispersion at others followed by re-concentration, but often with a different mix of herds.
6. The presence, or even the suspicion of rinderpest, would cause herdsmen to flee in the hope of avoiding its disastrous effects but in so doing they must have facilitated its spread on some occasions.

2.6.2. In the more distant past before vaccination was introduced, one could expect dramatic but short-lived and very infrequent outbreaks. The cattle population of a large ecological area would, in effect, be one enormous herd. Infective animals would mingle freely with susceptibles as herdsmen moved the groups of cattle to successive patches of grazing several times a day. A high percentage of the herd or group could, thus, become infected over a short period and death or recovery would follow at a similar pace. Cattle population densities would be reduced dramatically and the disease would, therefore, tend to die out until a new susceptible population had been re-established and re-introduction of infection occurred. Population susceptibility would return gradually as the second, third and later generations replaced the recovered animals that eventually died or were culled. With low fertility rates this replacement and herd build-up process could easily take ten to fifteen years.

2.6.3. In later years when settled agriculturalists took over an increasing proportion of the land the extent and routes of stock movement would be diminishing. Herd to herd spread would have been slower and could be prevented to some extent by prompt owner action to isolate the herd. Without fencing, however, it would have been difficult to prevent occasional contact, particularly among young stock, and the increasing intensity of contact brought about by reductions in available dry season grazing must have increased the chances of infection. Under these circumstances a smouldering, endemic, form of the disease could develop.

2.7. Effects of Vaccination

2.7.1. The introduction of a partial vaccination policy virtually converted the epidemic potential outlined in 2.6.2. to the conditions favouring endemic infection described in 2.6.3. Early campaigns were usually restricted to mature animals because of severe reactions in young stock. Furthermore, colostral immunity interferes with the response to vaccination in the young animal. Work at Vom (1964 - 65 Annual Report) has shown that such protection may inhibit the development of an active immunity for an average of nine months, though it can be for as little as five months and as long as one year. However, beyond this point vaccination should confer a life-time immunity so, at any one time, the proportion of the population which is susceptible is much reduced.

2.7.2. The extent of vaccine use not only determines whether rinderpest becomes endemic but also how the disease behaves when it is so established. Sufficient young animals must be available and move around the population at a pace which allows steady spread without causing a concentrated epidemic. Thus vaccination of adult cattle can probably contribute to the development of endemic infection.

2.7.3. In Table 1 the numbers of vaccinations, numbers of outbreaks and special notes for the years 1951 - 52 are listed. Since vaccination represented the largest component of the control programme, attempts were made to calculate the relationship between numbers of outbreaks in each year with the intensity of vaccination in the previous year. The use of such techniques as regression analysis was explored but the data was inadequate to give satisfactory results. However, it does appear that there should be a noticeable effect when the vaccination rate exceeds 10% and that a rate of about 30% per year should be sufficient to eliminate all outbreaks in the circumstances described. This higher rate should, in fact, amply cover the proportion of the cattle population represented by the six to eighteen months age group.

It would seem safe to conclude, therefore, that quite a low rate of vaccination should maintain a cattle population free of rinderpest once eradication has been achieved, even when the population is frequently exposed to new infection. Incidentally, it was also concluded that mathematical techniques merit further investigation on a larger body of more exact data with a view to possible wider applications in disease control planning.

Table 1

Rinderpest 1951 - 61 Vaccinations and Outbreaks — Northern Nigeria

Year	*Vaccinations thousands*	*Outbreaks*
1951	682	382
1952	816	345
1953	805	443
1954	891	376
1955	881	355
1956	736	360
1957	820	417
1958	932	490
1959	958	332
1960	1355	293
1961	1896	91

2.8. **Disease Patterns in Nigeria**

2.8.1. In Table 2 on the next page, some of the rinderpest outbreak data from Northern Nigeria for the period 1955 - 62 has been compared with various other factors, Province by Province (as the country was then divided). It can be seen that the numbers of outbreaks per thousand animals bear no obvious relationship to stocking densities. There are, however, indications of a relationship between incidence of rinderpest and the numbers of trade cattle moving through a Province. To those who know Nigeria this will not be surprising because trade cattle have long been recognised as the principal means of spreading the disease.

2.8.2. Seasonal migrations also appear to have played a part as indicated in Table 3.

Table 3.

Number of Rinderpest Outbreaks by Quarters of the year

Year	*Quarter of year*			
	first	*second*	*third*	*fourth*
1956	118	133	55	50
1957	105	112	71	35
1958	71	108	73	41
1959	171	123	87	48
1960	104	80	63	48
Total	569	556	349	222

The data was obtained from the archives of F.L.D. and is incomplete because figures from some Provinces were occasionally omitted from the returns.

Significant tests confirm real differences between the numbers of outbreaks in the first and second halves of the year and between those in the third and fourth quarters. Explanations may be found in the following summary of production patterns drawn from 'The Cattle and Meat Industry in Northern Nigeria' (Werlohn 1964).

January to March/April

Fodder is becoming scarce at this time and the cattle are in relatively poor condition. They are concentrated near rivers and water sources with grazing being restricted to fadamas. There is heavy localised movement between water and grazing and frequent contact between herds and animals can be expected. Thus the possibilities of rinderpest outbreaks would be very high.

Table 2

Rinderpest Outbreaks and Population Characteristics

Northern Region Provinces	Cattle Population (thousands)	Population Density Acres/Animal	Rinderpest Outbreaks 1955/6-1961/2	Outbreaks per 1,000 Animals	Trade Cattle Numbers (thousands) 1955/6-1961/2	Ratio of Trade Cattle Numbers: Cattle Population
Sokoto	1,087.5	25	375	0.34	931	0.86
Kano	900.0	12	263	0.29	598	0.66
Bornu	1,980.0	13	872	0.44	1,613	0.81
Katsina	525.0	12	175	0.33	356	0.68
Zaria	270.0	42	130	0.48	148	0.55
Bauchi	720.0	23	265	0.37	504	0.70
Adamawa	487.5	27	166	0.34	298	0.82
Plateau	487.5	9	174	0.37	314	0.64
Ilorin	97.5	117	60	0.62	659	6.80
Benue	187.5	96	52	0.33	300	1.60
Niger	487.5	38	109	0.22	170	0.35
Kabba	7.5	1,000	4	0.53	27	3.86
Sardauna	262.5	30	—	—	—	—
Total	7,500.0	24			4,405	0.59

1. Based on JP15 vaccination figures
2. Acreage from Agrometeorological atlas

April/May to June
As the rains start there is a general dispersion of herds over the whole of Northern area. Movement is greatest at this time of year as herdsmen go in search of fresh grazing. Possibilities of new contacts are, therefore, high, and high incidence could continue although the numbers of herds in any one outbreak would tend to be small. However, settlement of land for cropping puposes has gradually reduced the wet season grazing potential and increased risks of rinderpest associated with more extensive stock movement.

July to September
In this period all the herds have to be kept away from farmland crops and must avoid tsetse infested areas because of the dangers of trypanasomiasias. While these constraints restrict the area available for cattle, the grazing capacity is excellent and movement is much less intense. There is, therefore, correspondingly less contact between herds. This diminished movement pattern could explain the declining incidence of outbreaks in the third quarter.

October to December
As the harvest is gathered at the end of the rains, animals can move on to cultivated land to graze crop residues. Herd stocking densities are dramatically reduced and movement is more orderly so contact between herds and animals is much less than in the periods January to April and May to June. The drift of movement is slow and uniformly towards the south as the harvest progresses but begins to accelerate as fodder becomes less plentiful at the end of the year. Thus it would be reasonable to expect a generally low incidence of rinderpest during the fourth quarter of the year. It must be remembered, however, that a high proportion of whatever vaccination had been planned, would have been done during this period and could also have had favourable impact on incidence.

2.9. **Conclusions**

It seems clear therefore that stock movement and grazing capacity held the key to rinderpest spread in Africa and particularly in Nigeria. Trends towards settlement of stock and new movement patterns by truck should, therefore, bring hope of the final eradication of rinderpest from West Africa.

CHAPTER THREE

THE DEVELOPMENT OF RINDERPEST CONTROL IN NIGERIA

The behaviour of rinderpest and the response to control measures can be studied most easily on the basis of three time periods, beginning with the uncontrolled situation and passing through a period of partial control to the stage when eradication could be contemplated.

3.1. The Period 1886 - 1924

Rinderpest reached Chad from Dafour in 1886 and very quickly entered Nigeria. The effect was to devastate the fulani herds by, reportedly, killing 80 - 90% of all the animals in the region. The disease appears then to have become endemic with occasional isolated and small outbreaks. However, after a widespread drought and famine in 1912 - 13 there was another disastrous epidemic in 1913 - 14. One more occurred in 1919 - 20, again causing mortalities in the range of 60 - 90%.

3.1.1. The viability of the nomadic system must have been severely challenged by these epidemics and the confidence of the fulani in their way of life upset. Food supplies were, undoubtedly, threatened. Such income as had previously been obtained would have disappeared and debts were certainly incurred by stock owners in order to survive. The practice that developed of purchasing unborn calves for high prices indicates the extent of the problem of restocking that arose. St. Croix (1945) reports that as late as 1944 the fulani believed that their cattle were still inferior to the ones that were owned in 'the old times', indicating that long term repercussions had resulted.

3.1.2. It may be hypothesised that prior to the introduction of rinderpest the fulani were in ecological equilibrium with their environment. Sales and deaths of cattle should have balanced births and a steady proportion of breeding cows to other stock could have been maintained. Sudden and unpredictably high mortality undoubtedly changed this equilibrium. Having witnessed the decimation of his young stock the herd owner would have tended to increase herd size by retaining older cows in the hope of decreasing losses and a swifter re-establishment of the herd in the event of another outbreak. Short-term implications must have been a drastic reduction in the supply of animals to the meat market and, as was in fact reported, very high prices for replacements. Milk supplies must also have declined with fewer stock, lower quality and lower average productivity. Since herdsmen went into debt because both their sources of income were reduced, the rate at which the cattle population was re-established must have been compromised. Some owners probably went out of cattle keeping and became settled farmers. The establishment of rinderpest in Nigeria must, therefore, have had fundamental effects on the whole of agriculture and society.

3.1.3. The essential features of the period 1886 - 1924 could be defined as the uncontrolled nature of rinderpest and the very severe losses experienced by herds throughout Northern Nigeria leading to a tremendous loss of confidence and stability in cattle production. Uncertainty must have been compounded by the recurrence of epidemics at decreasing intervals with no apparent means of effective protection.

3.2. The Period 1924 - 60

3.2.1. A national rinderpest vaccination scheme was introduced in Nigeria in 1924, initially using double innoculation methods with serum and virus and, later, a single dose of dried goat tissue vaccine. By 1930 a network of vaccination camps had been established to operate annual voluntary programmes in which cattle were gathered for vaccination. Mortality in affected herds was reduced to less than 20% and even as low as 5% in some cases. As the number of animals vaccinated increased, the severity of the disease lessened and, eventually, the main mortality occurred among animals between six months and two years of age, after the resistance obtained from immune mothers had worn off and before they had been vaccinated or survived a challenge.

3.2.2. Rinderpest vaccine was given routinely to all trade cattle at this stage of the programme. Altogether, about 10% of the cattle population was covered each year from 1950 onward. Other control measures, including quarantine and slaughter of infected animals, were added. Legislation was also passed, making rinderpest vaccination compulsory, but it was not extensively implemented until late in the decade.

3.2.3. Although the neighbouring countries were also suffering from rinderpest and constituted a source of importation of disease in dry season migrations and among trade cattle, outbreaks were well reported and additional methods of quarantine, protective vaccination and limited slaughter of infected animals maintained a fairly healthy situation. However, towards 1960 the situation began to deteriorate again, as may be seen in Table 1 in Chapter 2, and the outbreak pattern in neighbouring countries is shown in Table 4.

Table 4

Rinderpest Outbreaks in Neighbouring Countries 1952 - 61 (Lepissier 1971)

Year	*NIGER*	*CHAD*
1952/3	64	213
1953	89	271
1954	337	47
1955	353	351
1956	161	173
1957	418	165
1958	377	351
1959	70	367
1960	30	235
1961	65	324

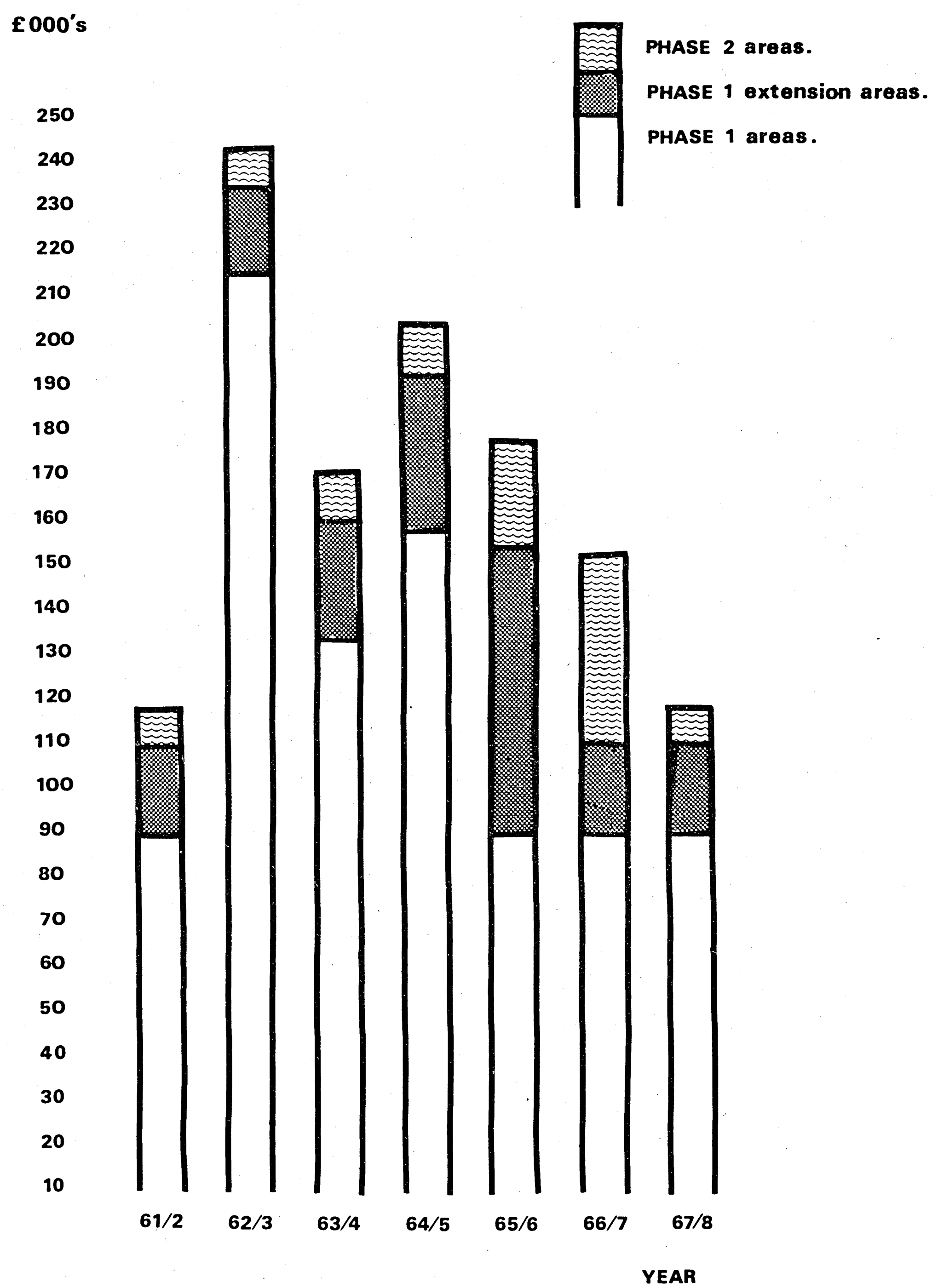
3.2.4. To summarise rinderpest development in Nigeria over this period, it can be said that the disease was brought under some measure of control as vaccination coverage was built up to between 8% and 13% of the national herd per annum and routine vaccination of trade cattle was added. A substantial proportion of the cattle population, therefore, must have been effectively protected. The disease ceased to cause devastating losses experienced in earlier years. From the limited data and commentary available it appears that cattle production began to stabilise again between 1928 - 38. Herd size did not increase and cattle were sold as the risks were seen to be diminished, and debts were payed off. Restored confidence then appears to have led to an expansion of the cattle population after 1938.

3.3. The Period 1960 - 76

3.3.1. Failure to make further progress in rinderpest control, the problem of interactions with other diseases and concern over the possibility of a worsening situation, when contrasted with impressive progress being made against contagious bovine pleuropneumonia and trypanasomiasis, heightened the desire for new initiatives against rinderpest in Nigeria.

3.3.2. The potential for international co-operation was demonstrated by a successful joint vaccination programme in Sokoto Province of Northern Nigeria and the neighbouring part of Niger. In Nigeria as a whole vaccination coverage was increased in 1961/2 and when Phase I of JP15 started in the 1962/3 dry season all the provinces north of the Niger and Benue rivers were included. While a single dose of vaccine properly prepared, handled and applied could be expected to give an adult animal a life-time immunity, a cautious policy of three successive annual vaccinations was decided upon by all the countries concerned. It was realised that operational difficulties would limit the numbers of animals that could be reached in each season and that many young stock would become susceptible after colostral antibody levels waned. Furthermore, the rigours of the climate might have affected the quality of vaccine by the time it was injected. The three campaigns must have involved the revaccination of some animals unnecessarily but each year effective immunity was obtained in a larger portion of the cattle population. Phase I, therefore, extended from the 1963/4 to the 1964/5 season. Phase II incorporated the few remaining cattle producing areas of Nigeria, mainly to the west of the Niger river, and was carried out in the dry seasons of 1964/5 to 1966/7.

FIGURE 1 Histogram of the annual total costs of rinderpest control.



3.3.3. National financial support for the rinderpest campaign was supplemented by foreign aid which was applied in different ways from country to country. Substantial amounts of laboratory and field equipment were supplied to Nigeria, small numbers of foreign staff gave specialised assistance and teams were provided to help with and co-ordinate the vaccination campaigns. Most of the routine work was carried out by national staff with the very effective support of native authorities.

3.3.4. The Vom Veterinary Laboratory was a major supplier of rinderpest vaccine for JP15 in other countries as well as Nigeria. According to Lepissier, costs for all countries, per dose applied, averaged the equivalent of 12.3 US cents from aid funds and 10.2 US cents from national funds giving a total of 22.5 US cents per dose. Nigerian costs averaged 8.1 US cents per dose and this was made up of 3.5 US cents in aid and 4.6 US cents from national funds. The types of vaccine used varied from country to country, and over the years, but tissue culture vaccine gradually replaced the goat adapted and rabbit adapted virus vaccines.

3.3.5. Following the intensive vaccination phases, Governments were expected to maintain annual programmes to immunise all young cattle between the ages of six months and two years. The entry of animals into the freed zones was strictly controlled and a stamping out policy with quarantines had to be applied to all outbreaks.

3.3.6. Developments in Nigeria are summarised in Table 5 on the following page. A very large proportion of the cattle population was vaccinated in the four recorded years of JP15 and in 1964 the proportion must have neared 100%. These high proportions must be contrasted with the average of 11.5% over the period 1951 to 1959, 16.7% in 1960 and 23% in 1961. Rinderpest outbreak numbers declined appreciably as vaccinations increased, from an average of 370 per year between 1951 and 1959 to 332 in 1960 and 283 in 1961. The subsequent fall, as can be seen, was dramatic and, apart from minor resurgences in the years of political difficulty and subsequent reorganisation, rinderpest has virtually disappeared from Nigeria.

Table 5

Outbreaks of Rinderpest and Vaccinations done 1962/63 - 1974/75

Year	*Outbreaks*	*Vaccinations Carried Out*		
		Trade Stock	*Breeding Stock*	*TOTAL*
1962/63	91	671,000	5,303,000	5,947,000
1963	2	639,000	5,491,000	6,132,000
1964	2	797,000	7,216,000	8;058,000
1965	3	793,000	3,535,000	4,328,000
1966	16			
1967	14	No data due to Socio-political problems		
1968	15			
1969	13			1,482,000
1970	75	Political reorganisation, data		2,992,000
1971	28	incomplete and aggregated		3,011,000
1972	5			2,055,000
1973	3*			2,126,000
1974/75	3*			1,161,000

* Unconfirmed cases

CHAPTER FOUR

THE COST OF RINDERPEST ERADICATION IN NIGERIA

A benefit/cost appraisal of a disease control programme involves a wide variety of considerations. Following a pattern established by a W.H.O. consultative group (WHO 1972) financially quantifiable benefits and costs will be defined and used to develop a benefit/cost ratio. Other benefits, to which specific values cannot be attached, will be reviewed and discussed so that policy makers may make their own judgements on the degree of importance to be attached to them. Although JP15 in Nigeria followed the general phasing that had been agreed internationally there was a certain amount of overlap between Phases I and II. For the purposes of financial calculation, therefore, transitional costs are indicated under the heading 'Phase I extension' where appropriate.

4.1. **Definition of Costs**

Prior to JP15 the Nigeria Government was already operating a vaccination programme and a control procedure for outbreaks. The new programme intensified these activities with the aim of achieving freedom from outbreaks and eventual complete eradication. Extra funds were required and a large part of these came from overseas aid sources. The Nigerian national contribution to JP15 consisted, largely, of funds that would have been used in a continuation of the previous programme. Following the intensive vaccination phases, national funds were required to cover the costs of surveillance and young stock vaccination and approximated the cost of the programme before JP15. Thus, the additional expenditures incurred over Phases I and II could be regarded as the true cost of JP15 for the purpose of benefit/cost analysis.

4.2. **Expenditures incurred**

4.2.1. **Foreign Aid:** The following Table 6 shows a summary of the international contributions to the Nigerian Campaign as indicated in the periodic and final reports:

Table 6

International Aid Contributions to JP15 in Nigeria

	Annual Costs in £					*TOTALS*	
Items/Year	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*1962/66*	*1962/67*
Staff	9,798	12,969	26,772	16,928	8,891	66,467	75,358
Recurrent	61, 286	26,440	42,332	36,369	21,434	166,427	187,861
Aid in kind	39,300	750	4,550	–	–	44,600	44,600
TOTALS	110,384	40,159	73,654	53,297	30,325	277,494	307,819*

* Equivalent to US $ 744,922 (at US $ 2.42 = £1)

4.2.2. **Nigerian Basic Costs:** The Nigerian national expenditure on rinderpest control covered a mixture of Native Authority executive work and the supervisory and diagnostic work carried out by the Northern Region Government. Since the figures for national costs varied to some extent, according to the available sources, it was necessary to reconcile the differences and arrive at a reasonable compromise.

a Lepissier (1969) states that £324,000 was spent in total in areas under JP15 agreements over the whole programme. Since the whole Northern Region was under the JP15 programme for three years, this represents an average of £108,000 per year for the whole region.

b Corroboration of this figure is provided by US AID costings of Nigerian expenditures in Phase I areas as follows:

Native Authorities	£50,000	
Government	£40,000	(reported in the proceedings
Vaccine	£ 8,500	of the Kano Meeting 1961)
TOTAL	£98,500	

If the average expenditure of £8,000 per year in the Phase II areas reported by Lepissier is added, the total for the whole country amounts to £106,500 per year.

c The following deductions could be made from the 1965/66 Estimates of Expenditure for the Government of Northern Nigeria. The Ministry of Animal and Forest Resources had a total recurrent budget of £987,535. About half of this was devoted to salaries and the rest to other expenses such as vaccines. The Animal Health Division had a salary component of £101,975 of which approximately 22% was allocated to rinderpest control as shown below:

1965/66 Nigerian Government Salary Costs

Officers' Duty	*% time on Rinderpest*	*Salary in £*	*Salary attributable to Rinderpest*
Senior Veterinary Staff	10	19,450	1,945
Laboratory Staff	10	17,705	1,770
Senior Vets	10	13,205	1,320
Field Laboratories	10	6,250	625
Technical Officers	50	11,445	5,722
Livestock Assistants	50	15,900	7,950
Vaccinators	100	3,185	3,185
Other Staff not on Rinderpest	0	14,835	0
		101,975	22,517

It is impossible, at this late date, to allocate precisely recurrent expenditures to JP15, but most of the vaccine and a large proportion of each of the other budgetary items would have been attributable to rinderpest work. Therefore, it seemed reasonable to assume that about half of the total shown in the following table could be allocated to JP15:

1965/66 Nigerian Government Recurrent Expenditures

Transport, vehicle running and replacement	£127,690
Labour	£ 16,500
Vaccines	£ 20,000
Equipment, refrigerators, fuel, etc.	£ 6,840
	£171,030

When staff costs (£22,517) are added to half the recurrent cost (£85,515), a total of £108,032 is obtained. The Nigerian national general support work done on rinderpest at the Vom Laboratory was valued at £9,000 per year.

d From these different assessments it was concluded that the base cost for the control programme that would have continued if JP15 or a national equivalent had not been introduced would have been £110,000 for general operations and £9,000 for basic laboratory services making a total of £119,000 per year.

4.3. **Other Items and Services**

In order to determine residual values to include among benefits the following costings were made according to Nigerian reference documents:

4.3.1. Large amounts of small equipment that may have lasted more than one year such as syringes, camp equipment and other field hardware were provided, but these were regarded as entirely used up in the campaign.

4.3.2. Eleven control posts were built as follows:

8 for Phase I	£28,000
1 for Phase I extension	£ 3,500
2 for Phase II	£ 7,000
	£38,500

4.3.3. Cold store equipment was provided in kind as follows:

Phase I	£7,400
Phase I extension	£ 750
Phase II	£ 750
	£8,900

Other cold store equipment was mainly for storage of vaccine at the divisional level; this was estimated at £100 per division thus totalling £4,200. The overall total for cold store equipment was £13,100.

4.3.4. Vehicles were provided as follows:

Phase I	21 Vehicles	£30,600
Phase II	4 Vehicles	£ 3,500
		£34,100

4.3.5. Extensive training was provided for personnel, especially of vaccinators, drivers and livestock assistants, many of whom passed into Government Service on the completion of their JP15 contracts. This meant that they were experienced when they entered the Government Service. Certain costs were involved but it was considered that they were more than off-set by the longer term capabilities available for other activities.

4.4. **The Role of Vom Veterinary Laboratory**

The Federal Department of Veterinary Research at Vom provided the vaccines and all the technical support services vital to the success of the control programme. Many advances in knowledge and techniques came to fruition during the course of the campaign but no value has been placed on them. The following are the extra costs incurred and these were met by US AID.

Year	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*TOTALS*
Recurrent	£3,033	£3,033	£3,033	£3,033	£3,033	£15,165
Capital	£4,750					£ 4,750

The recurrent item represented the cost of three technical officers.

4.5. **Costs of International Co-ordination**

International co-ordination was the element of cost of JP15 that was not easily divided among the collaborating countries. The approach adopted was to determine a cost per vaccination for the whole programme and allocate to Nigeria the amount that corresponded to the numbers of vaccinations carried out:

4.5.1. Overall co-rdination cost:

Phase I	£47,500 for 36.4 million vaccinations	=	0.13p per vaccination
Phase II	£68,400 for 24.45 million vaccinations	=	0.28p per vaccination

The increased cost in Phase II (including Phase I extension in Nigeria) was due to the fact that more inaccessible areas had to be covered and to the lower density of cattle populations in most of the areas concerned.

4.5.2. The vaccinations in Nigeria (thousands):

Phase I	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*TOTALS*
Nigeria	5,390	6,580	6,940	1,720	–	20,630
Phase II	–	–	150	170	160	480
Total Vaccinated	5,390	6,580	7,090	1,890	160	21,110

4.5.3. Costs of the International Co-ordination attributable to Nigeria:

Year	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*TOTALS*
Phase I	£7,007	£8,554	£9,022	£2,236	–	£23,891
Phase II	–	–	£ 420	£ 476	£448	£ 1,344
TOTAL	£7,007	£8,554	£9,442	£2,712	£448	£28,163

4.6. The Distribution of costs by Phase Area in Nigeria

4.6.1. The distribution of the cost prior to JP15 could be based on the rate of vaccine application in each area. The following table shows the results, assuming that unit costs were the same for all the areas:

AREA	*% of vaccinations attributable to the area*	*Operational Costs*	*Laboratory Costs*
Phase I	77.5	£85,250	£6,975
Phase I extension less Benue	17.5	£19,250	£1,575
Phase II including all Benue	5.0	£ 5,500	£ 450
TOTAL		£110,000	£9,000

However, there were minor differences in between unit operating costs in successive phases and the following are the estimates for each year in each Phase area after correction for the different working conditions suggested by Nigerian reference documents:

Phase I	£83,250	+	£6,975	=	£90,225
Phase I extension	£18,250	+	£1,575	=	£19,825
Phase II	£ 8,500	+	£ 450	=	£ 8,950
	£110,000		£9,000		£119,000

4.6.2. Wide variations in costs occurred between years as shown below:

For the Phase I Area:

a Pre JP15 costs (and assumed follow up cost) per year = £90,255

Annual average vaccinations = 650,000

Cost per vaccination pre JP15 = 13.9p

b During JP15 overall costs comprised:

Year	*1962/63*	*1963/64*	*1964/65*	*TOTALS*
Extra Costs	£125,174	£ 43,096	£ 66,674	£234,944
Nigerian Costs	£ 90,255	£ 90,255	£ 90,255	£270,765
Total Costs	£215,429	£133,351	£156,929	£505,709
Vaccinations (millions)	4.594	4.403	5.222	14.219
Cost/Vaccination	4.7p	3.0p	3.0p	3.5p

4.6.3. For the Phase I extension area:

a Pre JP15 costs per year £19,825

Annual average vaccinations 150,000

Cost per vaccination pre JP15 13.2p

b The costs during JP15 were as follows:

Year	*1963/64*	*1964/65*	*1965/66*	*TOTALS*
Extra Costs	£ 8,787	£15,191	£46,048	£70,026
Nigerian Costs	£19,825	£19,825	£19,825	£59,475
Total Costs	£28,612	£35,016	£65,873	£129,501
Vaccinations (millions)	0.899	1.277	1.463	3.639
Cost/Vaccination	3.2p	2.7p	4.5p	3.6p

4.6.4. For the Phase II area:

a Pre JP15 costs per year £8,950

Annual average vaccinations 25,000

Cost per vaccination pre JP15 35.7p

b The cost during JP15 were as follows:

Year	*1964/65*	*1965/66*	*1966/67*	*TOTALS*
Extra Costs	£ 4,254	£12,994	£33,806	£51,054
Nigerian Costs	£ 8,950	£ 8,950	£ 8,950	£26,760
Total Costs	£13,154	£21,954	£42,756	£77,814
Vaccinations (millions)	0.304	0.313	0.246	0.863
Cost/Vaccination	4.3p	7.0p	17.4p	9.0p

4.6.5. The distribution of costs year by year, for each phase shown in Fig. 1.

4.7. **The following table shows the changes in total expenditure** on rinderpest control from 1961/62, one year before JP15, to 1967/68, the first year of the maintenance programme. The base cost as determined in sections 4.2.3. and 4.2.4. is deducted from each year's total to give the additional cost attributable to JP15. The resulting total is £356,024. However, in order to compare these costs with the benefits dealt with in the next chapter it is necessary to make adjustments for the changing value of money over time by the discounting procedure discussed in Chapter 7. When a 10% discount rate is applied the 1962/63 value of costs becomes £310,962.

Table 7

Summary of Costs

AREAS		*1961/62* £	*1962/63* £	*1963/64* £	*1964/65* £	*1965/66* £	*1966/67* £	*1967/68* £
Phase I	Base	90,225	90,225	90,225	90,225	90,225	90,225	90,225
	Extra	–	125,174	43,096	66,674	–	–	–
Phase I Extension	Base	19,825	19,825	19,825	19,825	19,825	19,825	19,825
	Extra	–	–	8,787	15,191	46,048	–	–
Phase II	Base	8,950	8,950	8,950	8,950	8,950	8,950	8,950
	Extra	–	–	–	4,254	12,994	33,806	–
Total Cost		119,000	244,174	170,883	205,119	178,042	152,806	119,000
Base Cost		119,000	119,000	119,000	119,000	119,000	119,000	119,000
JP15 Cost		–	125,174	51,883	86,119	59,042	33,806	–

Total JP15 Cost is £356, 024.

4.8. **Conclusion**

It was planned that the maintenance programme would be phased out after a further short period of years when the risk of re-introduction of rinderpest had been removed. If this had been possible a permanent reduction in disease control costs could have been added to the benefits. However, there is no early prospect of such a development.

CHAPTER FIVE

BENEFITS OF RINDERPEST CONTROL

In this chapter the financially quantifiable benefits are presented and some of the unquantifiable benefits are discussed. Among the latter should have been the question of the impact of rinderpest control on herd structure and cattle populations but this proved to be so complex and important that it was considered worthy of a separate chapter (Six).

5.1. Physical losses avoided by the implementation of JP15

The main financial benefits of controlling and eradicating rinderpest are the elimination of specific mortality, improved fertility and avoidance of loss in milk and meat production. A series of projections were made with respect to the rinderpest problem that would have ensued in the absence of JP15. The simplest of these projections is a continuation of the pre-eradication average losses. However, with increasing population pressure and consequently increased movement of stock, incidence would almost certainly have increased. The character of the disease might also have changed in these changing circumstances so a number of possible alternatives was envisaged.

5.1.1. As indicated in Table 1, the numbers of outbreaks per year had remained fairly uniform over the decade prior to JP15. Relevant averages for the whole period are as follows:

Period	*1951 - 1960*
Outbreaks per year	376
Animals involved per year	33,334
Animals involved per outbreak	89
Animals dead per year	3,894
Proportion dead	11.68%

Increased control efforts, at Nigerian Government expense, resulted in fewer outbreaks in 1961 and 1962. However, the total numbers of animals involved in these outbreaks were higher than the ten year average and mortality among affected animals was almost exactly the same. Thus, it was necessary to allow for fairly wide variations in the possible character of the disease, in projecting losses avoided by JP15.

5.1.2. **Outbreak Projections:** A continuing rate of 370 outbreaks per year was chosen as a conservative estimate of the outbreaks that could have occurred with the continuation of the pre-JP15 programme in Nigeria. In subsequent sections this will be referred to as Assumption A. The possibility that incidence of outbreaks would have increased is covered by an Assumption B which was based on a build-up to the peak incidence seen in the 1950-61 period. The expected numbers of outbreaks implied by each assumption are shown below, together with the recorded outbreaks and mortality for years 1962/3 to 1973/4:

YEAR	*62/3*	*63/4*	*64/5*	*65/6*	*66/7*	*67/8*	*68/9*	*69/0*	*70/1*	*71/2*	*72/3*	*73/4*
1. Recorded outbreaks	91	2	3	1	16	14	15	13	75	28	5	0
2. Outbreaks expected without JP15												
Assumption A	370	370	370	370	370	370	370	370	370	370	370	370
Assumption B	370	386	402	418	434	450	450	450	450	450	450	450

5.1.3. The reported mortality resulting from rinderpest among animals affected in outbreaks since JP15 was completed has been within the range of 3–5%, but losses had been much higher in earlier years. Allowance had, therefore to be made for this type of variation and two mortality rates: 3% and 11.5%, appeared to represent the possible range adequately. These were designated Assumptions I and II respectively.

5.1.4. Further assumptions were needed with respect to variations in numbers of animals involved per outbreak. These numbers could have tended to become larger, as a result of increased movement, and the following average sizes have been chosen as representative of lower and upper limits after consultation with appropriate authorities:

Outbreak Size 1 : 95 animals involved
Outbreak Size 2 : 125 animals involved

5.2. **Calculation of Financial Benefits**

Many different series of calculations were undertaken with the above assumptions to explore their relative significance as well as the financial return that could be expected from each combination. Only a few of these will be presented, however, and they will be confined to mortality and reproductive effects. The bases for assessing losses in meat and milk production were more difficult to define and, as will be seen later, were not essential to the completion of the economic appraisal.

5.2.1. **Mortality avoided** was valued at £20 per animal. This sum now appears ridiculously low, as does the subsequent figure of £5 for a calf, but it was, in fact, the current price in northern Nigeria in the 1962/3 season. The values for each year are discounted at the rate of 10% back to 1962/3 which is regarded as the base year for this programme evaluation. The principles and implications of this discounted procedure are discussed in Chapter 7.

5.2.2. In Table 8a is shown the most conservative estimate of mortality loss avoided. The numbers of outbreaks recorded were deducted from the lower incidence projected for each year in Assumption A. Each outbreak was considered to affect the smaller numbers of animals implied by Assumption I and the lowest mortality rate of Assumption I was applied to the numbers of animals involved. Nevertheless, after discounting (at 10%) this mortality loss avoided, the 50 year benefit is very nearly £220,000.

In Table 8b the calculations and results with Assumptions B, 2 and II are shown. By the eleventh year a discounted benefit of £811,436 has accrued and over 50 years the total reaches nearly £1,300,000.

These two sets of results represent the lower and upper limits of this type of benefit and in view of the wideness of the range it was decided that average figures derived from the 1951 - 1960 findings (paragraph 5.1.1.) would be a fair basis on which to present the financial losses avoided. Recorded losses during JP15 could be ignored without prejudicing the result. The calculations and results will be found in Chapter 7, together with further discussions.

5.2.3. **Effects on the reproductive rate** could take two forms. Diseased animals that recovered could abort or their fertility could be reduced. The second effect is the increased numbers of calves that are produced by the animals that would have died if JP15 had not been introduced. No attempt has been made to calculate the loss avoided from the former of these two effects but the value of additional reproduction resulting from mortality avoided is shown in Table 9a for the most conservative set of assumptions (A, 1 and I) and in Table 9b for the average mortality avoided as defined in Paragraph 5.2.2. above. It will be noted that a calving index of 40% has been used in these calculations. Values for ten years only are taken into account because ecological pressures from 1973 onwards, as discussed in Chapter 6, could have nullified further benefits by necessitating management changes and new costs.

5.2.4. **Improved productiviity in meat and milk** has not been assessed for animals that would be expected to contract the infection but recover. However, it is generally accepted that such losses are not insignificant, even when partial vaccination is maintained as was the case in Northern Nigeria before JP15. Greater severity of such chronic diseases as trypanosomiasis could also be expected as a sequel to rinderpest. Some allowance should be made for the avoidance of such losses if a completely comprehensive appraisal of rinderpest control is desired but further survey and experimental evidence would be needed.

Table 8a

Lower Limit of Mortality Losses Avoided

	1962/63	*63/64*	*64/65*	*65/66*	*66/67*	*67/68*	*68/69*	*69/70*	*70/71*	*71/72*	*72/73*
Outbreaks avoided (A)	279	368	367	369	354	356	355	352	295	342	365
Animals involved (95 outbreaks) (1)	6,505	34,960	34,865	35,055	33,630	33,820	33,725	33,440	28,025	32,490	34,675
Mortality (3%) (l)	795	1,049	1,046	1,052	1,009	1,015	1,012	1,003	841	975	1,040
Value (£)	15,900	20,980	20,920	21,040	20,180	20,300	20,240	20,060	16,820	19,500	20,800
Values disc. at 10% (£)	15,900	19,071	17,280	15,801	13,783	12,606	11,415	10,291	7,855	8,268	8,029

Sub-totals	1962/63 - 1972/73	=	140,299
	*1973/74 - 1982/83	=	50,025
	*1983/84 - 2012/13	=	29,610
TOTAL (50 years)			£229,934

*Calculated in the same way as above on the basis of 370 outbreaks avoided each year.

Table 8b

Higher Limit of Mortality Losses Avoided

		1962/63	63/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73
Outbreaks avoided	(B)	279	384	399	417	418	436	435	437	375	422	445
Animals involved (125 outbreaks)	(2)	34,875	48,000	49,875	52,125	52,250	54,500	54,375	54,625	46,875	52,750	55,625
Mortality (11.5%)	(II)	4,011	5,520	5,736	5,994	6,009	6,268	6,253	6,282	5,391	6,066	6,397
Value (£)		80,212	110,400	114,712	119,887	120,175	125,350	125,062	125,637	107,812	121,325	127,937
Values disc. at 10% (£)		80,212	100,354	94,752	90,035	82,080	77,842	70,535	64,452	50,348	51,442	49,384

Sub-totals	1962/63 - 1972/73	= 811,436
	*1973/74 - 1982/83	= 306,876
	*1983/84 - 2012/13	= 181,643
TOTAL (50 years)		£1,299,955

* Calculated in the same way as above on the basis of 450 outbreaks avoided each year.

Table 9a

Lower Limit of Benefit from Improved Reproduction (1)

		1963/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73
Extra Calves	(2)	795	1,844	2,890	3,942	4,951	5,966	6,978	7,981	8,822	9,797
Value (£)	(3)	3,975	9,220	14,450	19,710	24,755	29,830	34,890	39,905	44,110	48,985
Values disc. at 10%	(£)	3,613	7,616	10,852	13,462	15,373	16,824	17,899	18,636	18,703	18,908
TOTAL		£141,886									

(1) Based on mortality avoided in Table a.
(2) Cumulative increase from reduced mortality in successive years.
(3) £5 per calf.

Table 9b

Average Benefit from Improved Reproduction (1)

		1963/64	64/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73
Extra Calves	(2)	1,200	2,800	4,400	6,000	7,600	9,200	10,800	12,400	14,000	15,600
Value (£)	(3)	6,000	14,000	22,000	30,000	38,000	46,000	54,000	62,000	70,000	78,000
Values disc. at 10%	(£)	5,454	11,564	16,522	20,490	23,598	25,944	27,702	28,954	29,680	30,108
TOTAL		£220,016									

(1) Assuming a calving rate of 40% and average mortality (paras. 5.2.3 and 5.2.2)
(2) Cumulative increase resulting from reduced mortality in successive years.
(3) £5 per calf.

5.3. Intrinsic benefits resulting from the programme

5.3.1. The training and skills acquired by staff as a result of the programme must have been extremely valuable. Vaccinators, drivers and clerical staff were recruited and trained for JP15 and they were skilled operators by the end of the programme. In consequence the Maintenance Programme was easier to operate and the same structure could be used for the JP28 programme to control contagious bovine pleuropneumonia which began in 1971.

5.3.2. Residual Value of Capital Investments

Some of the capital investments made in the course of JP15 had a residual value at the end of the programme and must be set against 'costs' or added to benefits. The appropriate items were identified in section 4.3. and the following depreciation factors applied to them in order to arrive at residual values.

ITEM	*DEPRECIATION FACTOR*
Control Posts	0.5
Vehicles	0.2
Cold Stores	0.2

The amounts to be credited as benefits to JP15 were as follows:

AMOUNT OF BENEFIT *£*	*REALISED IN (YEAR)*	*SOURCE OF BENEFIT*
190	1968/9	Vom equipment
7,000	1965/6	Phase I control posts
875	1966/7	Phase I extension control posts
1,750	1967/8	Phase II control posts
1,480	1965/6	Phase I cold stores
150	1966/7	Phase I extension of cold stores
150	1967/8	Phase II cold stores
840	1966/7	Cold stores for the divisions
6,120	1966/7	Phase I vehicles
700	1967/8	Phase II vehicles

The sum of these benefits for each year was:

YEARS	*1965/66*	*1966/67*	*1967/68*	*1968/69*
Benefits	£8,480	£7,985	£2,600	£190

These were discounted to 1962/63 values at 10% per annum and summed to give a total benefit of £13,546.

CHAPTER SIX

FACTORS AFFECTING THE PRODUCTION SYSTEM

Introduction

Rinderpest had catastrophic effects on Nigeria's livestock industry between 1884 and 1920 when control measures were first introduced. It continued to cause problems until 1963 when the JP15 programme almost brought an end to outbreaks. In the next decade the cattle population continued to grow until the drought greatly reduced the carrying capacity of the north. When this happened it was asked whether rinderpest eradication could have aggravated the results of the drought by encouraging overstocking.

In the light of this question it seems appropriate to explore the relationship between human population changes, land availablity, cattle population changes, herd characteristics and rinderpest. Data available is extremely limited so all that can be offered at this stage are reasoned views of such trends as are discernible and a commentary on their implications.

6.1. The Human Population in Northern Nigeria

The trend line for human population growth in Northern Nigeria depicted in Figure 2 represents the authors' interpretation of the various facts and views they could obtain in the limited time available. The line cannot be regarded as anything more than a rough approximation of the trend, but it does provide a basis for estimating the possible pressures on the use of land for purposes other than animal production.

6.1.1. The most reliable of recent figures are those of the 1963 census. They showed the population of Nigeria as a whole to be 55.7 million and that of Northern Nigeria to be 29.9 million. Reported figures for 1900, 1931 and 1952 were rather lower than indicated by the trend line but were, almost certainly, under-estimates due to enumeration difficulties in highly mobile populations. This view is supported by the fact that to attain the 1963 level and the level indicated (but not officially accepted) for 1973 would have necessitated a growth rate of more than 3% per annum from 1931 onward. Such a rate is far in excess of the 0.5% experienced in other rural-based economies and in Europe prior to the Industrial Revolution. Wilkinson in 'Progress and Poverty' (1973) states that most populations in pre-industrial societies have self-regulated mechanisms, and technological development is only undertaken when these mechanisms have broken down. There is no reason to suppose that Northern Nigeria is an exception to this hypothesis.

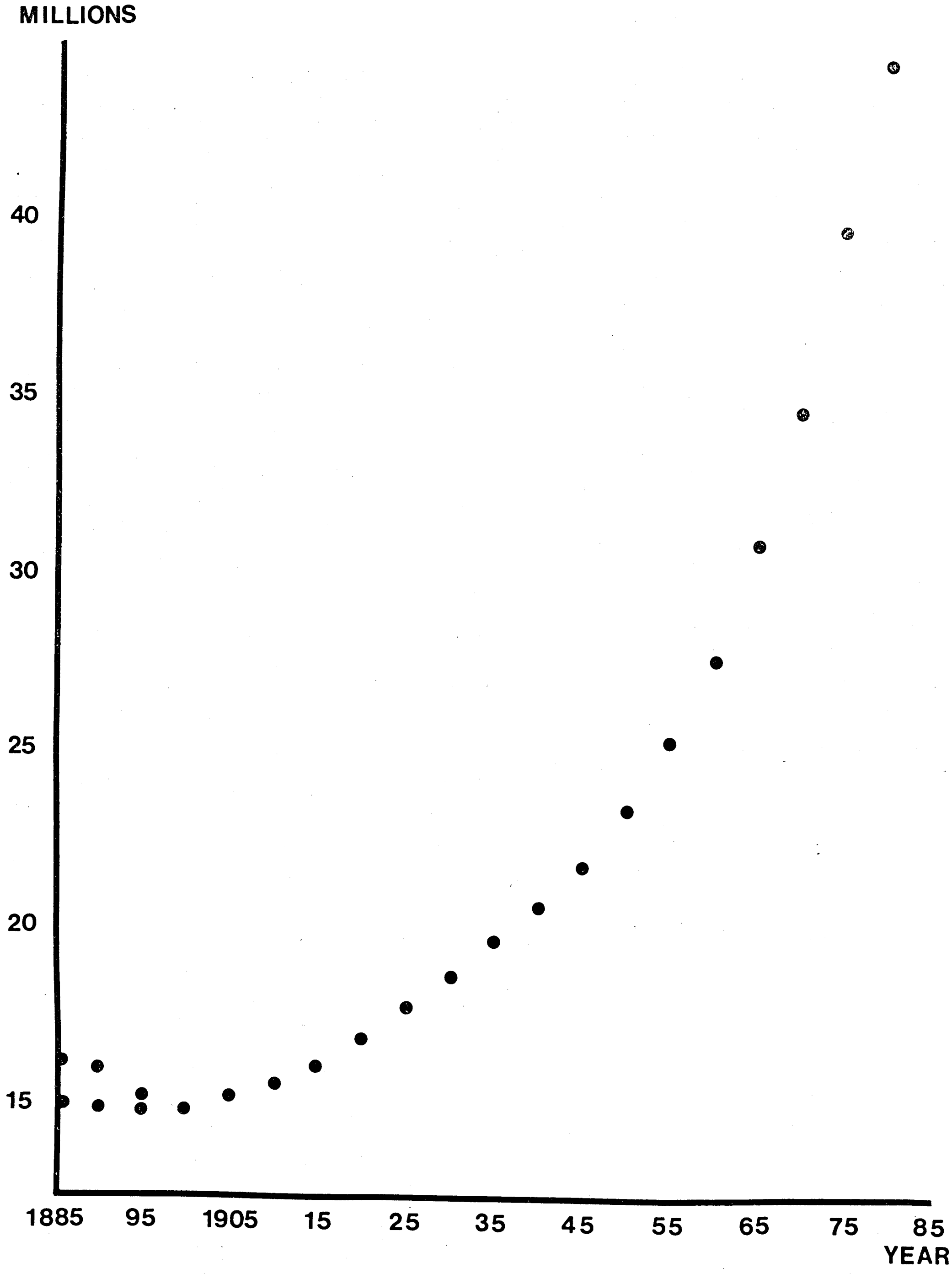
6.1.2. Bearing in mind the changes that have taken place in Northern Nigeria and the figures that were obtainable, the following growth rates were used to derive the trend line:

	Growth Rate
Until 1900	0
1900 - 1915	0.5
1915 - 1945	1.0
1945 - 1955	1.5
1955 - 1965	2.0
1965 - 1980	2.5

6.1.3. The resulting estimates of population numbers at five year intervals were as follows:

YEAR	*POPULATION IN MILLIONS*	*YEAR*	*POPULATION IN MILLIONS*
1885	15.0	1935	19.7
1890	15.0	1940	20.7
1895	15.0	1945	21.7
1900	15.0	1950	23.4
1905	15.3	1955	25.2
1910	15.7	1960	27.8
1915	16.1	1965	30.7
1920	16.9	1970	34.7
1925	17.8	1975	39.3
1930	18.7	1980	44.4

FIGURE 2 HUMAN POPULATION IN MILLIONS



6.2. Land Use in Northern Nigeria

A simple conceptual model of land use is presented in Figure 3.

6.2.1. Land in Northern Nigeria is allocated, for purposes of the present study, into two categories:

Type A 65 million acres: Tsetse free in the wet season and the dry season.

Type B 115 million acres: Tsetse free only in the dry season, infested in the wet season.

It is appreciated that the grouping into only two types of land is an over-simplification of the real situation. For example, it is known that some G. Morsitans affected belts may be unavailable all the year round. Also, the response to treatment of the savannah and riverine areas is known to be different. However, rather than to make a more complex model at this stage, it seemed preferable to explore the behaviour of a two sector model and to assume that the carrying capacity figures used allow for localised variations in land availability.

6.2.2. Included in Type B are the Benue and Mambilla Plateaus which are tsetse free all the year round. In fact they were not utilised until 1908 and the 1920's respectively. These add an assumed 0.7 million cattle to the wet season carrying capacity (present population) and are available for dry season grazing as well.

6.2.3. In 1963 the human population was distributed in approximately equal numbers between the two types of land, and is assumed to have maintained this pattern throughout the period under consideration.

6.2.4. Estimates of the amount of land used for purposes other than livestock grazing were based on various surveys and reports from the State Ministries, as well as a detailed survey of North East State carried out by the Land Resources Division of the UK Overseas Development Ministry, (L.R.D.). It was deduced that the area used is 1.25 acres per person on Type A areas and 1.0 acres per person in the Type B areas. This land is, therefore, considered to be unavailable for grazing.

6.2.5. By subtracting from the totals the amounts needed for other purposes, land available can be estimated:

Trends in land availability for grazing purposes (millions of acres)

YEAR	*Type A*	*Type B*	*TOTAL*	*YEAR*	*Type A*	*Type B*	*TOTAL*
1885	55.6	107.5	163.1	1935	52.8	105.1	157.9
1890	55.6	107.5	163.1	1940	52.1	104.7	156.8
1895	55.6	107.5	163.1	1945	51.4	104.2	155.6
1900	55.6	107.5	163.1	1950	50.4	103.3	153.7
1905	55.4	107.4	162.8	1955	49.3	102.3	151.6
1910	55.2	107.1	162.3	1960	47.6	101.1	148.7
1915	54.9	107.0	161.9	1965	45.8	99.7	145.5
1920	54.4	106.6	161.0	1970	43.3	97.7	141.0
1925	53.9	106.1	160.0	1975	40.4	95.4	135.8
1930	53.3	105.7	159.0	1980	37.2	92.8	130.0

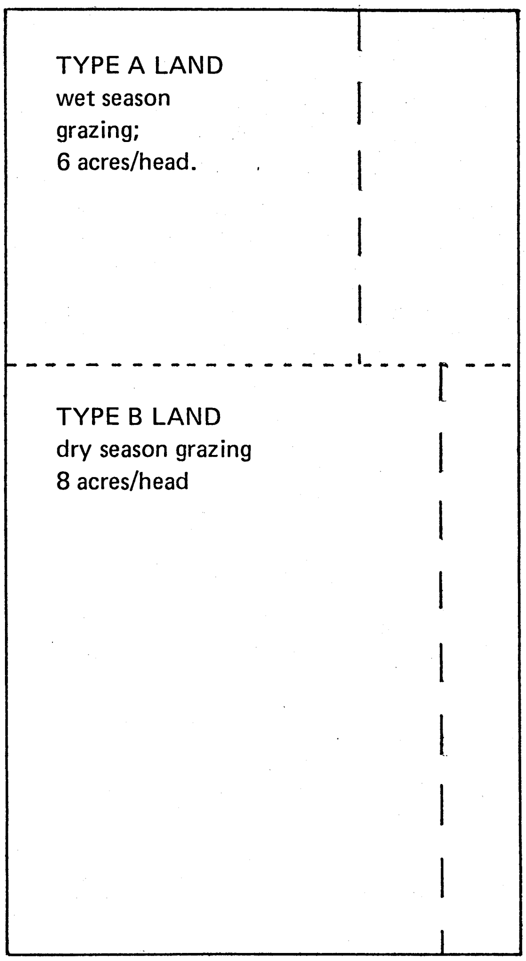
6.3. The Cattle Carrying Capacity of the Land

6.3.1. The year round carrying capacities are based on the L.R.D. survey of North East State as well as the experience of ranches that were visited. Papers from A.B.U. (de Leeuw 1974) were also consulted for this purpose. The following are assumed to be the year round carrying capacities:

Type A land 24 acres per animal assuming:
Sahel Zone : 30 acres per animal and Sudan Zone 23.5 acres per animal.

Type B land 12 acres per animal assuming:
Northern Guinea Zone : 15 acres per animal and Southern Guinea Zone : 10 acres per animal.

FIGURE 3 Carrying Capacity Model of Northern Nigeria



The vertical boundaries are between cultivated and other land unavailable for grazing on the right, and grazing land on the left. The boundaries move left as the human population increases.

This boundary is not fixed. It can move down as a result of tsetse clearance. It may fluctuate with climatic variations.

Northern Nigeria is seen as consisting of two types of land;

Type A land that is available for grazing in the wet season as it is tsetse free.

Type B land that is unavailable in the wet season but is available for the dry season.

Type B land does in fact contain two Plateau areas that are tsetse free and are assumed to add 0.7 million cattle to the carrying capacity in the wet season.

The human population is distributed equally between the two types and uses land such that it is unavailable for grazing at 1.25 acres/person in Type A areas and at 1.0 acres/person in Type B areas. The boundary between the two types represents the transition zone between acceptable and unacceptable tsetse risk in the wet season.

It is moveable permanently by tsetse clearance.

6.3.2. This gives a potential average carrying capacity for Northern Nigeria of 15 acres per animal when weighted by the proportional distribution of land according to climatic zones, but before taking into account limitations due to tsetse infestation. Using the total land availability from Table 6.2.5., and the carrying capacity of each class of land, the following total cattle carrying capacities are obtained (millions of cattle):

YEAR	*Carrying Capacity*	*YEAR*	*Carrying Capacity*	*YEAR*	*Carrying Capacity*
1885	10.87	1915	10.79	1950	10.25
1890	10.87	1920	10.73	1955	10.12
1895	10.87	1925	10.67	1960	9.90
1900	10.87	1930	10.60	1965	9.70
1905	10.85	1935	10.53	1970	9.40
1910	10.82	1940	10.45	1975	9.05
		1945	10.37	1980	8.67

The trend is shown in Figure 4 as the 'Year Round' line.

6.3.3. When seasonal limitations on the use of this land due to the tsetse fly are introduced the picture appears quite different.

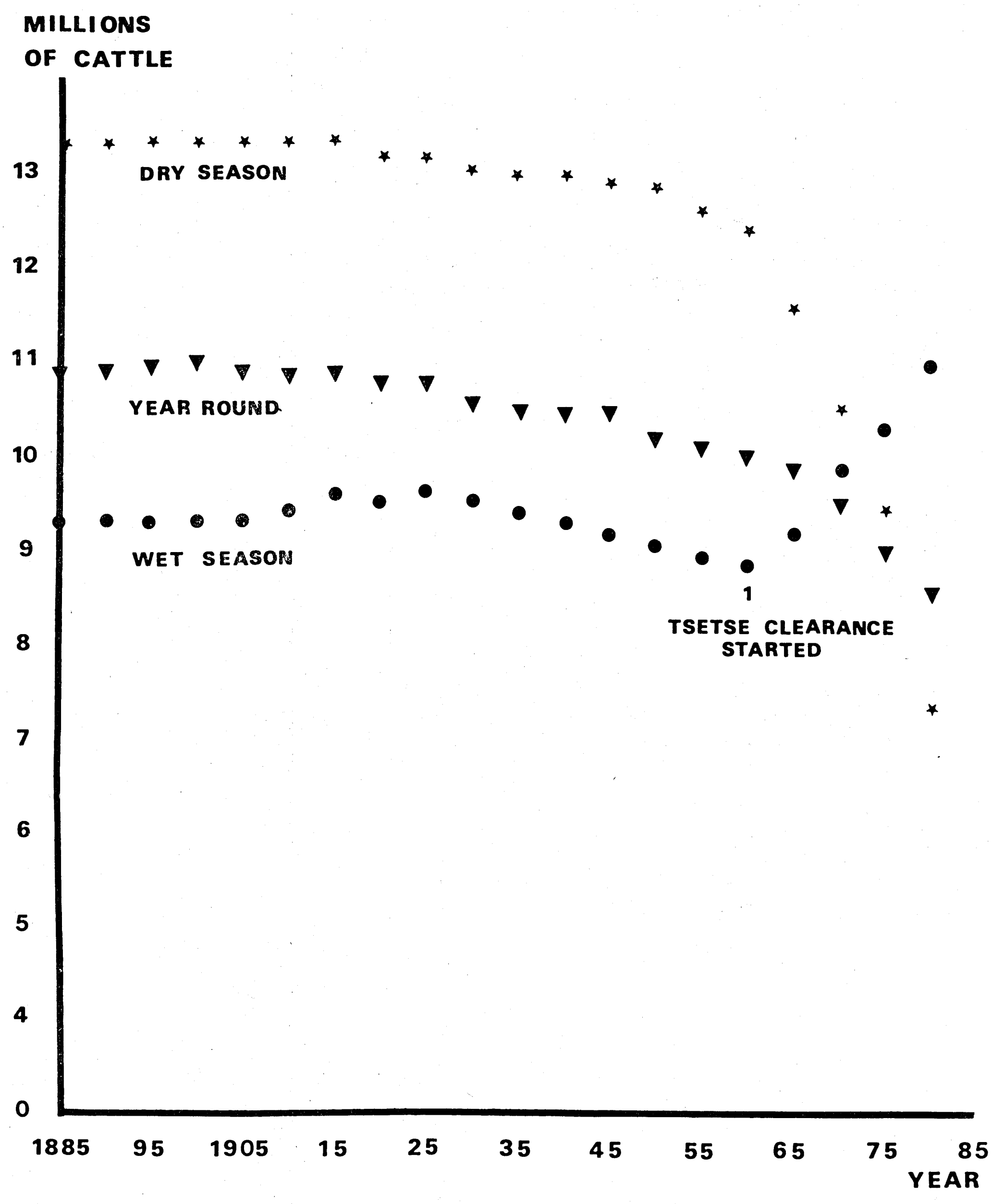
Type A land has been defined as the only area available for grazing during the wet season as it is tsetse free. This period is, generally, from mid-June to mid-September; the carrying capacity of the land appears to average six acres per animal. Type B land is available for the rest of the year. At the end of the wet season a large proportion of cattle moved onto Type B land. Thus, the equivalent carrying capacity of this land during the dry season appears to be about eight acres per animal.

If these carrying capacities are applied to the amounts of land available in each category the following changes in numbers of animals that can be reasonably supported can be noted:

Relative Carrying Capacities (millions of cattle)

YEAR	*Type A land*	*Other*	*Total tsetse free land*	*Type B land*
1885	9.27	–	9.27	13.43
1890	9.27	–	9.27	13.43
1895	9.27	–	9.27	13.43
1900	9.27	–	9.27	13.43
1905	9.23	–	9.23	13.40
1910	9.20	0.20	9.40	13.40
1915	9.15	0.50	9.65	13.40
1920	9.07	0.50	9.57	13.30
1925	9.98	0.70	9.68	13.30
1930	8.88	0.70	9.58	13.20
1935	8.79	0.70	9.49	13.10
1940	8.68	0.70	9.38	13.10
1945	8.57	0.70	9.27	13.00
1950	8.40	0.70	9.10	12.90
1955	8.21	0.78	8.99	12.75
1960	7.93	0.95	8.88	12.45
1965	7.63	1.62	9.25	11.70
1970	7.22	2.64	9.86	10.60
1975	6.74	3.60	10.34	9.40
1980	6.21	4.90	11.11	7.40

FIGURE 4 CARRYING CAPACITY OF THE LAND



6.3.4. Areas cleared of the tsetse fly are assumed to pass into use as wet season grazing with a consequent reduction in their dry season carrying capacity. This reduces overall dry season carrying capacity. Hence Type B land carrying capacity falls rapidly in the 1970's. Increased crop production or aforestation on Type B land would further reduce livestock production potential. Once the wet season carrying capacity is equal to the dry season carrying capacity, extra tsetse clearance will not increase the total carrying capacity.

6.3.5. The implications of these projections of land availability for livestock can be seen more clearly from Figure 5a. If tsetse fly clearance had not been undertaken the availability of wet season grazing could have become a major constraint on further expansion of livestock numbers between 1960 and 1965. As a result of the programme, the cattle population could, in theory, grow until early in the 1970's when the total land area expected to be available for livestock becomes the main limitation. The new implication is that further tsetse clearance would not benefit the industry unless rapid changes in land use technology could be introduced.

6.4. The Cattle Population Trends

Historical evidence on the livestock industry and the effects of rinderpest must now be related to theoretical land availability and carrying capacities.

6.4.1. It seems reasonable to assume that the cattle population of Northern Nigeria, prior to the entry of rinderpest, was in equilibrium with the environment. The cattle owning Fulani were the basis of the Fulani Jihad which conquered most of Northern Nigeria in 1800 - 1820 and maintained an apparently stable system thereafter. It seems unlikely that an unstable economic base could have supported this.

Movement patterns (see 2.8.) were probably much the same as today, but the migration range could have been shorter because a greater abundance of dry season grazing would have been available closer to the wet season grazing areas. The main risks involved were probably well known and disastrous mortality should have been rare. The system could, thus, have been stable within the limits of climatic variation. In dry years, fertility would be less, due to poor nutrition, but mortality from trypanosomiasis could have been lower than expected because, in dry years, the seasonal tsetse fly belts would probably have been less extensive. In wetter years animal nutrition could have improved, and hence fertility. However, mortality from trypanosomiasis need not have risen because grazing of marginally affected areas would have been unnecessary. In these ways cattle production was probably buffered against excessive rates of increase by management and cultural practices and from excessive decreases in the population by the behaviour of the biological system.

The pre-rinderpest carrying capacity, determined by the extent of Type A land must have been in the region of 9.1 to 9.25 million cattle. This is assumed to have been the population in the 1880's but it could, of course, have been less.

6.4.2. As mentioned earlier, rinderpest was first reported in Nigeria in 1887 and caused high mortality in this and the 1913/14 and 1919/20 epidemics. St. Croix (1945) described the herds as decimated, and in the light of this and other information, mortality rates of 80%, 70% and 55% respectively have been assumed for these epidemics.

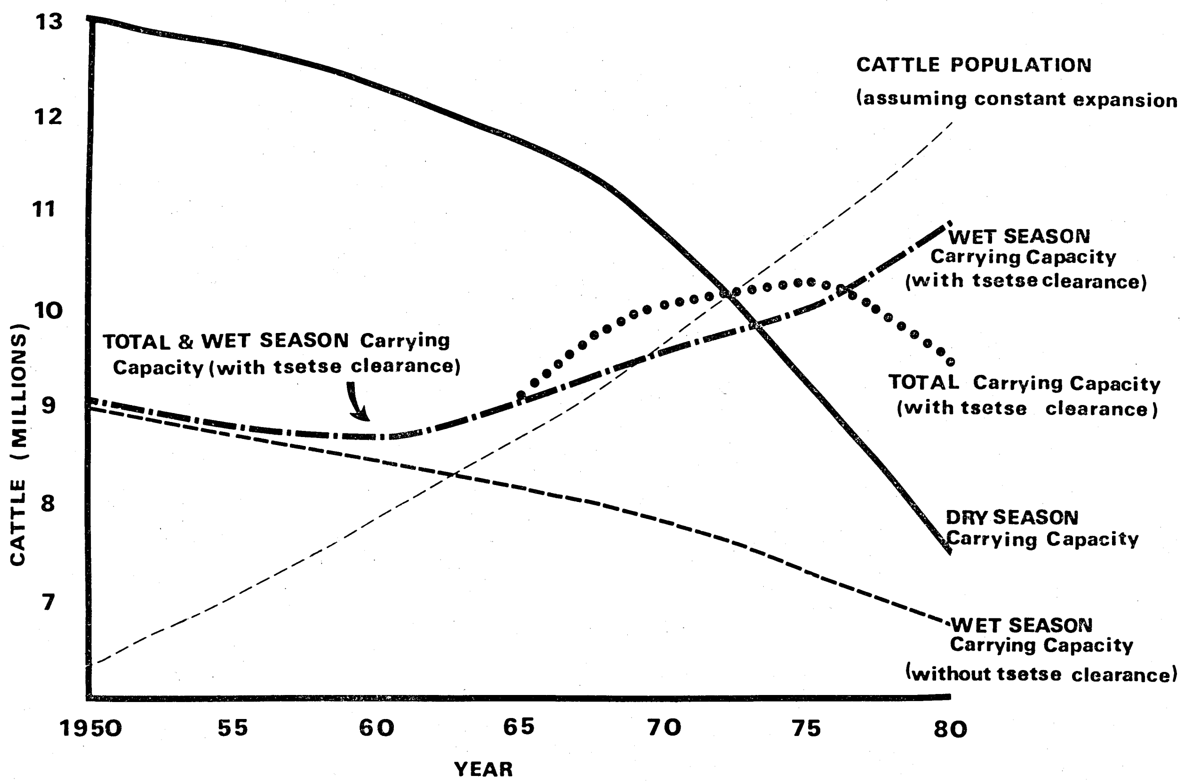
Restocking would have occurred as quickly as possible, so as many animals as possible would have been kept. The growth rate that can be achieved by herds under Nigerian conditions seems to be about 7%, with 2 - 3% offtake as casualty slaughter. This growth rate of 7% is assumed for the herds recovering from an epidemic.

However, debts would have been incurred as a result of the epidemics and these would have been paid off as soon as the risks allowed. This is why in 1908/9 the growth rate may have slowed to 2 - 3% and the offtake increased to 7%. After vaccination had become established in the late 1920's and the disease was less severe in its effects, sales of cattle were such that the population did not grow between 1928 - 38 (Ford (1971).

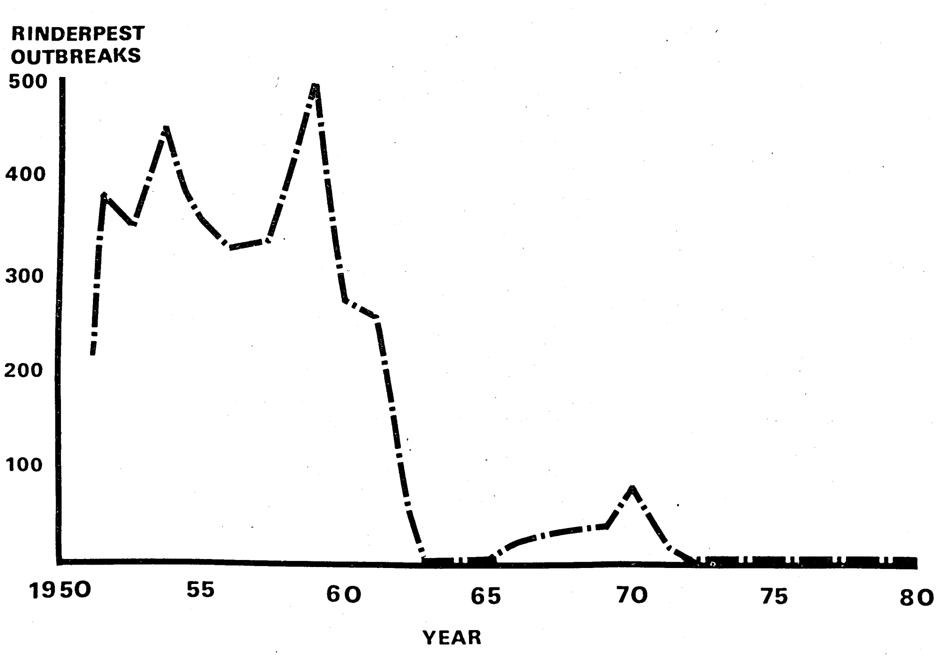
The extent of the fluctuations that are believed to have occurred in these early years is depicted in Figure 6 by the 'Real Population' trend.

6.4.3. The 1948 Annual Report for the Northern Region mentions the cattle population as having doubled over the previous decade, indicating a growth rate of around 7% per annum. From 1950 it is generally accepted that offtake increased again to about 7% and that growth rate of the cattle population decreased to about 2% per annum. This is supported by evidence that cattle numbers on which Jangali tax were paid only increased by about 2% per annum throughout the 1950's. The figures of cattle population have been projected through the 1960's to 1980 assuming that the conditions did not change and that the population would continue to grow at 2% over the whole time. Up to about 1968 these figures must have been close to the real population as judged by marketing information.

FIGURE 5

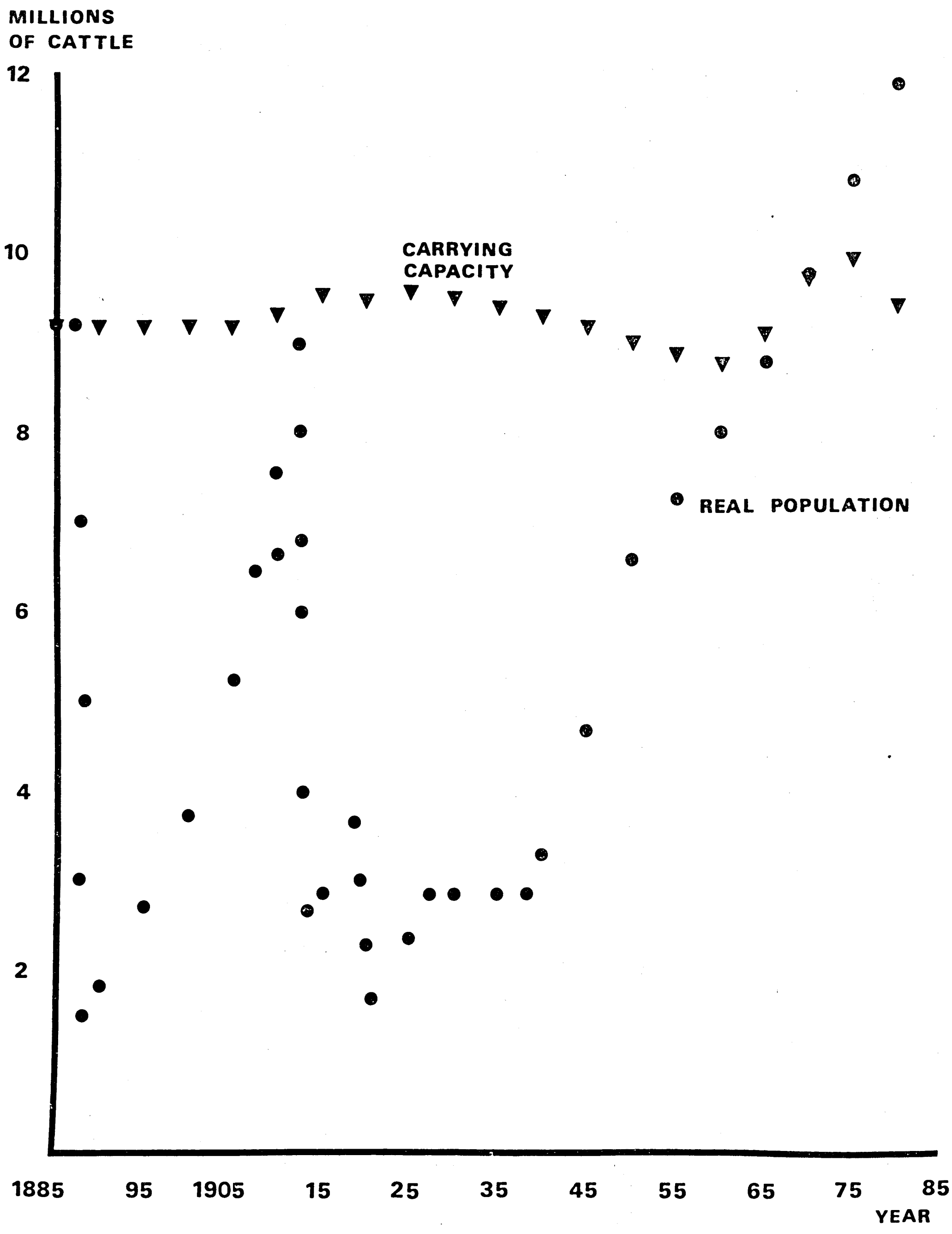


A) CARRYING CAPACITIES



B) RINDERPEST OUTBREAKS

FIGURE 6. CATTLE POPULATION OF NORTHERN NIGERIA



6.4.4. Cattle population trends (in millions) in Northern Nigeria would appear to have been as follows:

YEAR		*YEAR*	
1887	9.1	1920	7.71
1888	1.66	1925	2.39
1890	1.9	1928	2.93
1895	2.67	1938	2.93
1900	3.74	1940	3.36
1905	5.24	1945	4.71
1910	7.35	1950	6.60
1913	9.01	1955	7.29
1914	2.70	1960	8.05
1915	2.89	1965	8.88
1919	3.70	1970	9.81

6.4.5. As has already been pointed out, the cattle population did not reach the limit of carrying capacity of the country until after 1970. Some evidence of ecological pressures began to appear about 1968/69, however, after the completion of JP15 and prior to the 1972 drought. Increases in female cattle slaughterings became apparent in 1968/69 and increased from then on. During the drought they became very high indeed in some areas. There is evidence that the highest percentages occurred in trade cattle from the countries to the north. In the Report on Livestock in Nigeria (C.D.C. 1971) it is stated that a female slaughter rate of about 40% would be associated with a roughly stable level of breeding stock and this was supported by a simple modelling approach using Nigerian herd parameters. It seems that the rate of population growth slowed in 1968 and then started to decline from about 1971. The decline became more rapid during the drought of 1972/73, was stemmed for a while, but is believed to be declining again due to very heavy consumer demand.

6.5. The Implications for and of Rinderpest

6.5.1. The responses of stock owners to the devastating effects of the first three rinderpest epidemics must have been defensive. They appear to have opted for larger herds and retained older cows beyond their normal productive life in order to minimise the risk of extinction and maximise the possibility of rapid recovery after attacks of rinderpest.

6.5.2. Although vaccination was increasingly used from 1924 onward, high mortality was not uncommon in improperly vaccinated herds and numbers of outbreaks remained high enough for the sense of risk to persist. Since carrying capacity does not appear to have been a limiting factor there would have been no need for owners to adopt more intensive culling.

6.5.3. The success of JP15 in eliminating outbreaks of the disease must have restored producer confidence and enabled them to concentrate more on productivity than on survivability of their animals. Willingness to send an unusually high proportion of females for slaughter from 1968 onwards suggests that the removal of the rinderpest risk enabled owners to respond to ecological pressures by changing herd structure towards greater efficiency. It may be argued, therefore, that JP15 was more likely to have lessened the impact of the drought which began in 1972 than to have increased the problems that were experienced. Further support for this view may be drawn from the fact that the numbers of animals saved by JP15, as projected in Chapter 5, represented such small proportions of the total cattle population that rinderpest eradication per se could not have contributed significantly to the overgrazing problem in the drought.

CHAPTER SEVEN

DISCUSSION AND CONCLUSIONS

From the evidence which has been gathered, it is possible to conclude that the returns to international funds invested in JP15 were good and that a number of additional benefits ensued.

7.1. **Benefit : Cost Findings**

To assist those who are not familiar with benefit : cost analysis procedure the comparison of findings from Chapter 4 on costs and Chapter 5 on benefits will be undertaken step-by-step.

7.1.1. The various costs of rinderpest control before, during and after JP15 were summarised in Table 7. It was decided that estimated annual expenditures at the rate of £119,000 prior to JP15 could be regarded as 'basic' costs during JP15 and that they would have to continue indefinitely if relative freedom from rinderpest is to be maintained. The results of JP15 can, therefore, be attributable to the extra costs incurred in the Phase I and Phase II intensive vaccination schemes which were as follows:

YEAR	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*TOTAL*
Extra Costs	£125,174	£51,883	£86,119	£59,042	£33,806	£356,024

7.1.2. The range of financial benefits is provided by Tables 8 and 9 in Chapter 5 and an average benefit can be calculated as follows. First only the mortality avoided and the value of it at 1962/63 prices of £20 per animal:

YEAR	*1962/63*	*1963/64*	*1964/65*	*1965/66*	*1966/67*	*TOTAL*
Mortality Avoided	3,000	4,000	4,000	4,000	4,000	19,000
Value	£60,000	£80,000	£80,000	£80,000	£80,000	£380,000
Total Value to date	£60,000	£140,000	£220,000	£300,000	£380,000	–

The benefit of 4,000 deaths avoided each year continues into perpetuity.

7.1.3. The benefits and costs are compared to show whether the project is, in fact, worthwhile. 1962/63 is chosen as the base year as this is the first year of the project, and is called Year 0. 1963/64 is called Year 1 and so on. If these costs are added together and then subtracted from the total benefits, by the end of the main programme in 1966/67 there is £23,976 net benefit on mortality avoided alone and this accumulates at the rate of £80,000 per year thereafter. If Year 10 is taken as the horizon for accounting purposes, the total net benefit by then is £505,976.

7.1.4. Because of the long time scale over which benefits accrue and costs are incurred it is normal economic practice to discount the values for each year to a base year for the purposes of comparison. The rationale for this is that £1.00 is valued differently depending on the time at which it is received. The value is less if it is received in the future, as it could have been invested now, and be worth more than £1.00 later. The discount rate used is a reflection of the return that the programme funds could have produced in their best alternative use.

7.1.5. There are two possible approaches that may be used in comparing the return of projects competing for funds. The first is to choose a discount rate that reflects the rate of return in the society, and discount the costs and the benefits. At the time of this evaluation (1976/77) a 10% discount rate was appropriate for internationally funded projects. However, in the early 1960's when the JP15 project was being planned, the expected discount rate was 5%. This latter rate is also included to illustrate the large differences that can result with different rates. The total of the discounted benefits gives a measure of what the benefits of the programme are worth at the base year, and similarly the sum of the discounted costs represents the present worth of the costs. The ratio of the present worth of the benefits and the present worth of the costs is the benefit : cost ratio, and the project with a higher benefit : cost ratio is preferable to one with a lower benefit : cost ratio.

Discounted Rate	*Total Value of the discounted* *COSTS*	*BENEFITS to Year 10*	*For Years 0 - 10* *Benefit : Cost ratio*
5%	£331,514	£677,739	2.04
10%	£310,962	£551,565	1.77

7.1.6. The other approach is to subtract the costs from the benefits for each year to obtain the net benefit or cost for each year, and then to find the rate of discounting which will make present worth of the flow equal to zero. The rate of discounting which fulfils this condition is called the internal rate of return. When the costs and benefits are discounted separately using the internal rate of return as the discount rate, the benefit : cost ratio is, of course, equal to 1.00.

The table below shows the calculations:

Benefit minus cost discounted values for each year

Discount Rate	*Year 0*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5-10 inclusive*	*TOTAL*
0%	-£65,174	+£28,117	-£6,119	+£20,958	+£46,196	+£80,000	+£634,324
45%	-£65,174	+£19,391	-£2,910	+£ 6,875	+£10,450	+£35,890	+£ 4,522
47%	-£65,174	+£19,127	-£2,832	+£ 6,598	+£ 9,893	+£32,840	+£ 452
48%	-£65,174	+£18,998	-£2,794	+£ 6,465	+£ 9,628	+£31,432	- £ 1,445

The internal rate of return is between 47 and 48%.

7.1.7. If the value of improved reproductive capacity (£220,016) is added from Table 9b the discounted benefit over ten years increases to £771,581. If the discounted benefit represented by the residual capital value of certain JP15 investments (£13,546) as deduced in section 5.3.2., is also added, the total becomes £785,127. The benefit : cost ratio then becomes £785,127 : £310,962 or 2.48 : 1.

7.1.8. Even at the lower limits of benefits from mortality avoided over 50 years (£219,934) and improved reproductive capacity over ten years (£141,886), discounted benefits (£361,820) exceed costs (£310,962) by more than £50,000. If the higher limits of benefits are applied, exceptionally high returns of more than 5 : 1 can be demonstrated.

7.1.9. Yet another economic consideration must also be discussed. If it should, in time, prove possible to eliminate the basic maintenance cost of £119,000 per annum the saving involved would represent a further financial benefit attributable to JP15.

7.2. Further Considerations

7.2.1. The real cost of JP15 to Nigeria as a whole was very small, as most of the increased costs were met from aid sources. The main cost for Nigeria was that of extra personnel utilised in the programme, especially the drivers, innoculators and other operational staff. However, there was considerable urban unemployment in Nigeria, and the staff would be mainly recruited from these sources. Furthermore, the work was done in the season when there is very little demand for agricultural labour, so other activities were not disrupted. Thus, the use of actual costs rather than opportunity costs resulted in over rather than under-estimation. In general, benefits should be valued at the border price, as should all goods that enter the calculation.

7.2.2. A further consideration is the fact that Nigeria is an importer of cattle, and the price of cattle increases from the North to the South. The average Northern price in 1962/63 was approximately £20, and this is the value used because any shortfall in supply would be felt in the North.

7.2.3. The economic aspects of the programme could have been investigated before its implementation. The conclusions do not seem to be sensitive to any of the assumptions used in calculating the benefits. In general, it may be preferable to state an Internal Rate of Return rather than to use a standard discount rate to work out a benefit : cost ratio, because this avoids the difficulty of selecting the most suitable discount rate to use.

7.3. Unquantified Effects of JP15 and Other Observations

7.3.1. The training and experience gained in JP15 could be regarded as a long term benefit of considerable value. It paved the way, among other things, for the initiation of JP28 aimed at the eradication of contagious bovine pleuropneumonia.

7.3.2. The discussions, in Chapter 6, lead to the conclusions that JP15 paved the way to an improvement in cattle herd structure and could not have contributed significantly to overstocking in the drought period. This latter problem was the product of fundamental changes in land availability for grazing purposes which reached a critical stage around 1970.

7.3.3. The corollary to these conclusions is that further tsetse control, which increases the availability of wet season grazing and major development schemes which are bringing other major ecological changes, must be carefully integrated with the introduction of new livestock production technology if the cattle population is not to be severely depleted.

SUMMARY

The clinical characteristics and epidemiology of rinderpest are reviewed and it is concluded that movement patterns in West Africa led to severe and widespread but short-lived epidemics until vaccination was introduced in 1924. Thereafter the disease became endemic, with incidence declining to a level of 200-400 outbreaks per year in Northern Nigeria and following a seasonal pattern associated with stock movement patterns.

By 1960 it had become evident that a new initiative was required to remove the remaining rinderpest problem. Mortality still reached high levels where vaccine coverage had been inadequate. In concert with neighbouring countries Nigeria, therefore, undertook Joint Project 15 (JP15) and despite difficulties of continuity during the civil war rinderpest was virtually eradicated by 1972.

Expenditures on the programme in Northern Nigeria were examined and it was concluded that a basic sum of £119,000 per annum represented the cost of the pre-eradication programme, the Nigerian contribution during the JP15 and the cost of the maintenance programme following JP15. The additional cost of the intensive vaccination, mainly covered by foreign aid, amounted to £356,024. Discounted at 10% this represented a cost of £310,912.

Benefits, based on mortality and reduced reproductive capacity and discounted at 10% per annum, ranged between £361,820 and more than £1.5 million according to projected levels of disease avoided. Averages based on the 1950-1960 experience led to net benefits totalling £785,127 by the eleventh year and a benefit-cost ratio of 2.48 : 1 and an internal rate of return of more than 47% per annum.

The evolution of the livestock industry of Northern Nigeria and the involvement of rinderpest were considered at length. It was concluded that the entry of rinderpest introduced a new major hazard and led to the keeping of larger herds with an abnormally high proportion of aged cows as a defensive measure.

A simple land use model was used to examine various inter-relationships and led to the conclusion that JP15 paved the way to a return to a more efficient cattle herd structure prior to the drought and that it could not have contributed significantly to overstocking in the drought period. Further conclusions indicated an urgent need for closer integration of land use planning with further efforts at tsetse control and other major development projects.

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